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GEOLOGY OF THE SUMMER RANCH AND NORTH PROMONTORY MOUNTAINS, UTAH

by

O. Clair Adams

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Geology

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1962

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ACKNOWLEDGMENT

The author is grateful to Dr. Clyde T. Hardy, Dr. J. Stewart Williams, and Dr. Donald R. Olsen for suggestions concerning the preparation of this manuscript. Stanley S. Beus advised the author in the field. Dr. Grant Steele and Jack M. Balderas of the Gulf Oil Company identified fusulinid collections.

O. Clair Adams

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INTRODUCTION

General Statement

The Summer Ranch and North Promontory Mountains have not been studied in detail geologically, although the surrounding mountains have been extensively investigated. Within the limits of this area, sedimentary rocks of Mississippian through Permian crop out. Sedimentary and volcanic rocks of Tertiary age are also exposed. Extensive Lake Bonneville deposits underlie the valleys and overlap the foothills.

The purposes of this study are: (1) to describe the structure, stratigraphy, and geologic history of the area, (2) to prepare a geologic map of the area, and (3) to relate the stratigraphic features of this area to those of the surrounding region.

Location of Area

The area studied is bordered on the north by the Utah-Idaho state line and on the east by Blue Creek Valley. Utah State Highway 83 and Great Salt Lake form the southern boundary and Curlew Valley, south-southwest from Snowville, Utah, defines the western limit (Figure 1).

The mapped area lies completely within Box Elder County and covers a total of about 529 square miles. The Utah division of the Thiokol Chemical Corporation is located near the southeast corner of the mapped area.

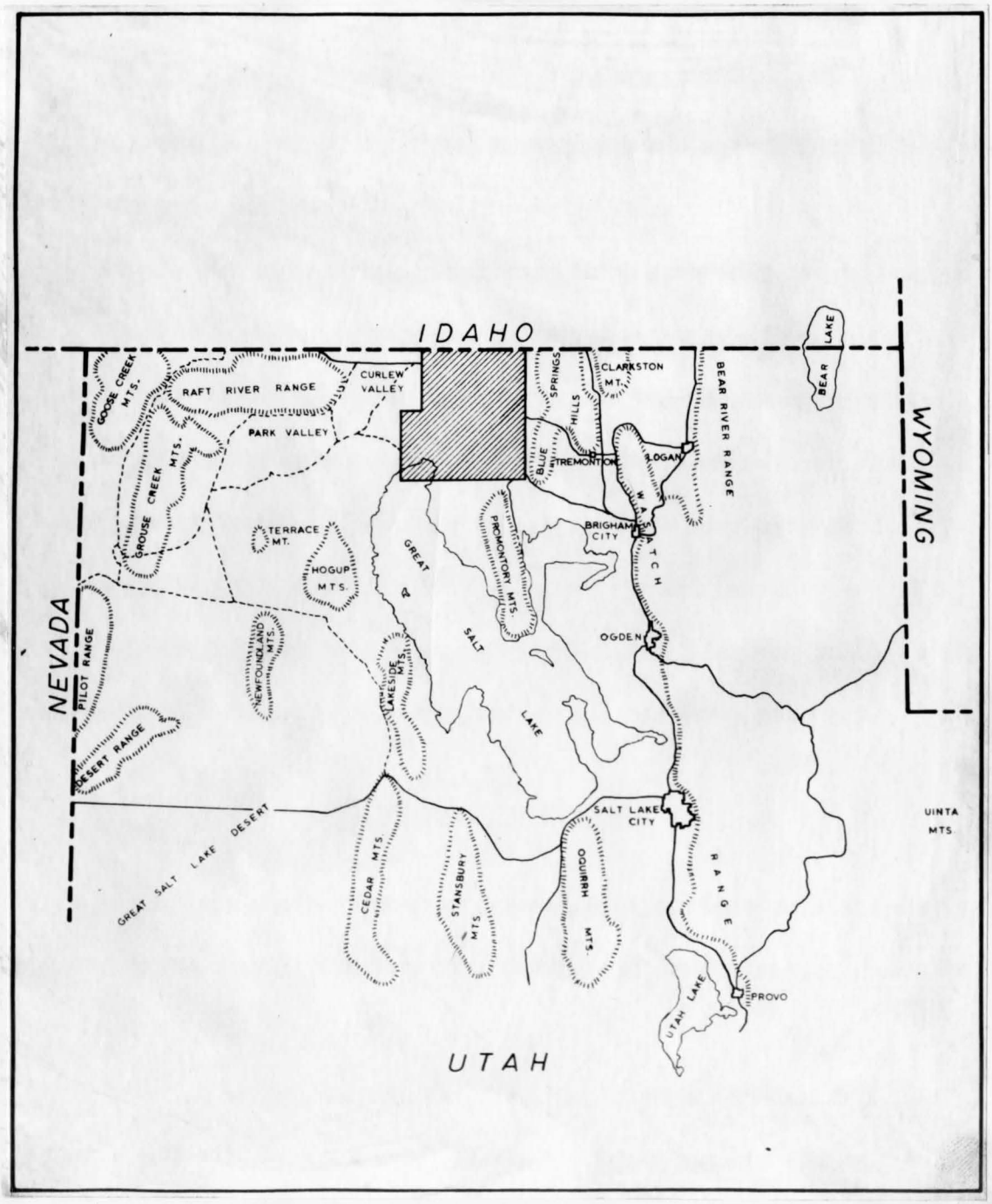


Figure 1. Index map of northern Utah.

Field Work

Initial field work was begun in August of 1960. Investigation of the mapped area plus near-by areas was carried on continuously through September of that year and intermittently until June, 1961.

Access roads are mainly unimproved but are passable by passenger car. Water is available at most of the ranches in the adjoining valleys and at several springs in the North Promontory and Summer Ranch Mountains.

Structural and stratigraphic details were plotted on vertical aerial photographs in the field. Information was subsequently transferred to a topographic map at a scale of 1:62,500, which was enlarged from a U. S. Geological Survey map, then traced on a transparent overlay. Stratigraphic sections were measured with a Brunton compass or with a steel tape.

Previous Investigations

No previous complete geologic investigation has been made of the area covered by this report. Various local features within the mapped area have been studied.

Walter (1934, p. 178-195) describes the structural relations of the Hansel Valley earthquake of 1934. Additional investigation concerning the structure of Hansel Valley was conducted by Adams (1938). Tertiary stratigraphy of Cache Valley was studied by Adamson (1955). Adamson reported the occurrence of tuffaceous rocks, similar to those in Cache Valley, in association with basalt flows near Snowville, Utah. Smith (1953, p. 74)

diagrams the southern limit of the Snake River basalt flows and showed that they covered the northern part of the area concerned in the present investigation.

STRATIGRAPHIC GEOLOGY

Strata of Paleozoic and Cenozoic age are exposed in the mapped area. The oldest formation that crops out is the Mississippian Great Blue limestone. The massive, poorly bedded, blue-gray limestones of the Great Blue are overlain by the distinctive black shales and red-brown quartzites of the Manning Canyon formation. Although fossil evidence in the area studied is inconclusive, the age of the Manning Canyon is inferred to be Chesterian and Springeran.

The Oquirrh formation represents deposition from lower Atokan through upper Wolfcampian time. This is an extremely thick section of limestone, sandy limestone, calcareous sandstone, and orthoquartzite. The Oquirrh formation constitutes the majority of the mountains within the mapped area. The top of the Oquirrh formation is not exposed in the Summer Ranch or the North Promontory Mountains.

If Mesozoic strata were deposited in the mapped area they were completely removed by erosion before the deposition of the Tertiary Salt Lake formation. The tuff and tuffaceous sandstone of the Salt Lake formation was deposited with pronounced angular unconformity on the Paleozoic rocks of the region. The late Miocene and Pliocene Salt Lake formation was deposited in a continental environment in contrast to the marine environment of the Paleozoic rocks.

The advent of Lake Bonneville during the Pleistocene epoch provided the depositional environment for widespread accumulations of well-sorted gravel, sand, silt, and clay. White tuffaceous detritus of reworked Salt Lake formation characterizes many outcrops. The highest elevation of the lake surface was about 5,135 feet (Williams, 1952, p. 1,375). The maximum limit of the Lake Bonneville shoreline defines the lower limit of outcrop of pre-Quaternary sediments in much of the mapped area.

Mississippian Rocks

During Mississippian time gentle subsidence characterized the area, and thick carbonate deposits accumulated. In the mapped area the Mississippian system is represented only by limited exposures of Great Blue limestone and the lower part of the Manning Canyon formation. Environments of the Manning Canyon continued from early Chesterian well into Springeran time without any major break. The Mississippian-Pennsylvanian systemic boundary is not shown in the area by any pronounced lithologic change. This boundary is defined in near-by areas by invertebrate fossils (Hebertson, 1957, p. 80).

Great Blue limestone

The Great Blue limestone is a thick-bedded finely crystalline blue-gray limestone. In the area covered by this report, massive limestone beds form rough ledges. Minor amounts of black chert are present in nodules and stringers, and thin interbedded shale beds are present. The Great Blue

limestone crops out in the mapped area only in the extreme southeast corner. Neither the top nor the bottom of the formation is exposed; therefore, a measurement of total thickness is not possible.

The limestones of the Great Blue are described by Gilluly (1932, p. 34) as being thick and monotonous. The upper and lower limestone units with the included Long Trail shale total 3,600 feet thick, according to Gilluly, in the Stockton and Fairfield quadrangles. About 15 miles south of the area covered by this report the Great Blue (?) limestone is in excess of 2,150 feet thick (Olsen, 1956, p. 59). In the West Mountains west of Portage, Utah, the Great Blue limestone is 1,180 feet thick (Stanley S. Beus, personal communication).

Fabrophylum sp. and Meekopora sp. are the only fossils identified from exposures of the Great Blue limestone. Numerous fragments of crinoid stems and bryozoans were noted but not identified.

Environment of deposition

Deposition of the Great Blue limestone occurred under somewhat more stable conditions than did the younger Paleozoic rocks of the area. The massive dense limestone, characteristic of the formation, was deposited in relatively undisturbed neritic environments.

The dominant chemical limestones indicate tropical to subtropical climatic conditions at the time of deposition. The depth of deposition was probably between about 75 and 175 feet. Elias (1937, p. 410), from his study of the Big Blue (Mississippian) of Kansas, reports that most corals lived at

a depth of 90-150 feet, most bryozoans occurred on sea bottoms between 75 and 100 feet deep, and that most articulate brachiopods were found at depths of between 90 and 160 feet.

At times, currents washed fine clastic sediments far out into the basin. Minor interbedded shale layers and fine sandy layers are present within the section exposed. Calcarenites and hydroclastic limestones were also formed by the action of fluctuating water.

Regional stratigraphy

The Summer Ranch and North Promontory Mountains lie within the area occupied by the Paleozoic Cordilleran miogeosyncline. The tectonic framework of this gently subsiding basin, with the hinge line ("Wasatch Line" of Kay, 1951, p. 14) and shelf area to the east, controlled sedimentation throughout the Paleozoic era. In north-central Utah the upper Mississippian rocks, from sections on either side of the hinge line, show that the basin to the west subsided at a rate of five to ten times as rapidly as did the shelf area to the east (Crittenden, 1959, p. 63).

The Mississippian Great Blue limestone is the oldest formation that crops out in the mapped area. Spurr (1895) described the rocks of the Mercur mining district of central Utah and applied the name "Lower Intercalated Series" to most of the Mississippian strata. He also proposed the name Great Blue limestone for exposures in that area. A type locality was never designated but, the name has been retained and is deeply imbedded in the geologic literature of northern and central Utah. From exposures in

the Oquirrh Mountains, central Utah, Gilluly (1932, p. 34) reported a thick monotonous sequence of limestone containing only a minor amount of clastic material. To this formation he applied the name Great Blue. The Mississippian section at Dry Lake, described by Williams and Yolton (1945), compares closely lithologically to the section of Great Blue limestone in the southern Oquirrh Mountains. Carr and Trimble (1961, p. 181) describe a Mississippian section in the Deep Creek Mountains of southeastern Idaho. This section is similar to the above mentioned Utah sections both lithologically and faunally. Exposures of the Great Blue limestone in the mapped area are believed to represent one of the upper limestone units of the above mentioned sections.

The shelf deposits of the western Uinta Mountain area that represent the equivalents of the Great Blue limestone are the upper sandstones and limestones of the Humbug formation and the interbedded black shales, dark limestones, and brown-weathering sandstones of the Doughnut formation.

The eastern Nevada equivalents of the Great Blue limestone are clastic wedges composed of coarse detrital material derived from the central Nevada positive area. This highland was created by the Antler orogeny (Sadlick and Schaeffer, 1959, p. 1,786). These formations are the Chainman, Diamond Peak, and Tonka.

Mississippian and Pennsylvanian Rocks

The Chesterian and Springeran series are represented by distinctive dark-colored shales and light-gray, dark-brown-weathering orthoquartzite

beds of the Manning Canyon formation. The stable environment of deposition which had persisted throughout most of the Mississippian was replaced in Chesterian time by more rapidly changing conditions. The Manning Canyon formation consists almost entirely of detrital material. Variations in particle size attest to these fluctuating conditions.

Manning Canyon formation

In the area covered by this report, the prominent units of the Manning Canyon formation are light-gray to light-brown siltstones, orthoquartzites, dark-gray shales, and black shales. No sample within the section measured indicated the presence of calcium carbonate when treated with dilute hydrochloric acid.

The formation is exposed only in a limited area in the northeastern portion of the Summer Ranch Mountains. The limonite-stained orthoquartzite beds stand out as prominent ledges above the smooth slopes formed by the dark-colored shales. Most exposures of the siltstone and orthoquartzite are stained brown and reddish brown on the weathered surfaces (Plate 1). Many outcrops show intense deformation of the orthoquartzite units. Slickensided surfaces are common on the large loose blocks. The shale is difficult to study because of its low resistance to weathering. The presence of a shale unit is usually evidenced only by a smooth covered slope. The shales act as aquicludes and several springs are present in the area at the contact of these shales and the silty units.

Figure 1. Limonite staining on weathered surface (lower part) and along bedding planes (upper part). From upper part of unit 13 of measured section No. 3 (see Appendix).

Figure 2. Hematite along bedding planes. Note truncated cross-bedding. From upper part of unit 13 of measured section No. 3 (see Appendix).

Plate 1. Manning Canyon orthoquartzite.

The Manning Canyon-Oquirrh contact is placed where the dominant shales and orthoquartzites are overlain by medium-gray limestones, sandy limestones, and calcareous sandstones. This contact reflects the deformed nature of the Manning Canyon formation. The contact seems to show minor thrusting in some areas, but this relationship is not thoroughly understood and would require much more field work for satisfactory explanation.

The following fossils were collected from the Manning Canyon formation:

Lingula sp.	Composita sp.
Chonetes sp.	Spirifer sp.

Environment of deposition

In the Chesterian series, a greater amount of clayey sediments were carried into the basin. The environment of deposition of the Manning Canyon shale was one of restricted currents and calm water conditions. The abundance of organic matter present, giving the shales their distinctive black color, is indicative of a recently elevated land mass, that was covered with a thick layer of mature soil, not too far away acting as a source area.

Twenhofel (1939, p. 1,178-1,198) outlines the necessity of restricted currents for the formation of black shales. Basins which lack circulation develop a reducing environment. With the absence of oxygen, sulfur in the organic material reacts to form hydrogen sulfide, then further reaction with sulfates present forms dilute sulfuric acid. Most bacteria are unable to live in this toxic environment. Decomposition of organic products is retarded and many complex organic compounds are buried without being altered

(Twenhofel, 1939, p. 1,178-1,198). The interbedded sandstone and orthoquartzite layers represent periods of widely fluctuating currents. Cross-bedding is present in some layers. The grain size is uniform and the grains are subrounded to rounded suggesting shallow epinertitic deposition.

Thickness of the formation and size and percentage of sand particles increase to the east across central Utah. An eastward source area is certainly indicated (Moyle, 1959, p. 88). Oscillating conditions continued through lower Springeran time (Plate 2).

Regional stratigraphy

Spurr (1895) described an "upper shale" unit at the top of the "Great Blue" limestone. Gilluly (1932, p. 31) redescribed this "upper shale" and assigned the name Manning Canyon shale to exposures in Soldier Canyon of the southern Oquirrh Mountains. Detailed studies of this formation have been made by Hebertson (1957, p. 36-38) and Moyle (1959, p. 59-92) in central Utah.

Moyle reports that shale constitutes 61 percent of the formation at the type locality in Soldier Canyon. The remainder consists of limestone 34 percent, quartzite 3 percent, and siltstone 2 percent. No limestone has been observed within the formation in the area covered by this study. The three dominant rock types in the section of Manning Canyon in the Summer Ranch Mountains are: (1) shale 49 percent, (2) orthoquartzite 35 percent, and (3) siltstone 16 percent (see section No. 3 in Appendix).

Plate 2. Manning Canyon formation. Black shale at bottom grades into siltstone at center which grades upward into orthoquartzite. Note upward increase in thickness of orthoquartzite beds (section shown is 25 feet thick). Unit 3 of measured section No. 3 (see Appendix).

East of the type locality the medium-bedded black fossiliferous limestone and dark-gray chert of the upper Doughnut formation is equivalent to the lower part of the Manning Canyon shale and the Round Valley limestone correlates with the upper part of the Great Blue limestone. In the Dry Lake section, southwest of Cache Valley, the silty limestones and shales of unit No. 5 of the Brazer formation (Williams and Yolton, 1945, p. 1,145) are suggested by Williams (1958, p. 33) as correlative lithologically with the Manning Canyon formation.

The red Darwin sandstone and the Amsden formation consisting of shale, siltstone, and light-gray cherty limestone represent early Pennsylvanian and possibly latest Mississippian deposition in southwestern Wyoming. These are the shelf equivalents of the Manning Canyon formation.

The Brazer and Wells formations in southeastern Idaho are not separated by a shale equivalent to the Manning Canyon formation. The Brazer formation represents late Mississippian and early Pennsylvanian deposition. In south-central Idaho (Carr and Trimble, 1961, p. 181) report the presence of strata similar to the Manning Canyon formation of northern Utah. West and southwest of the mapped area in northeast and east-central Nevada the shales and fine-grained orthoquartzites grade into the upper Tonka sandstone and the upper Chainman shale (Figure 2).

Pennsylvanian and Permian Rocks

A tectonic framework essentially the same as that described for the Mississippian system governed sedimentation throughout the Pennsylvanian

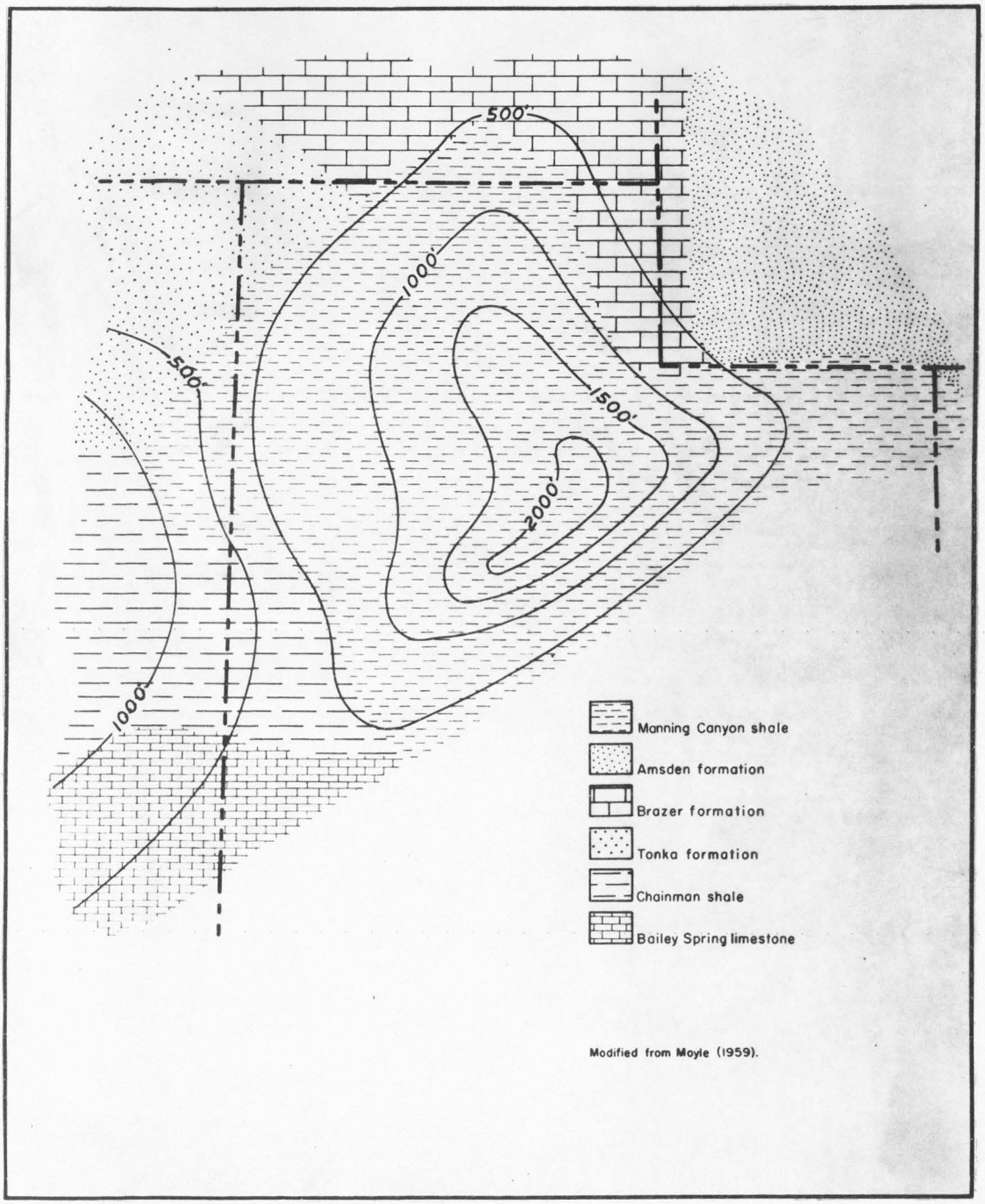


Figure 2. Isopachous map of Manning Canyon formation and equivalent units.

and Permian systems of the eastern Great Basin. Steele (1960, p. 91) suggests that tectonically and sedimentationally, the Pennsylvanian-Permian of the eastern Great Basin appears to have been deposited on an unstable shelf (within the miogeosyncline) with subsidiary intracratonic basins and uplifts. Figure 3 represents a generalized map of tectonic elements during late Paleozoic time. It is not inferred that these elements persisted throughout all of Pennsylvanian and Permian time but they were important factors in governing marine sedimentation of the area.

Through much of the Pennsylvanian and lower Permian time the area covered by this report received clastic and chemical sediments. The thick Oquirrh formation represents deposition from lower Atokan to upper Wolfcampian time.

Oquirrh formation

The major part of the mapped area is underlain by the Oquirrh formation. Much of the area is covered by mantle and good continuous exposures are rare. The lower Oquirrh consists of gray limestone and tan sandy limestone. The dominant rock type is finely crystalline medium- to dark-gray limestone. Bedding is generally well developed. Massive medium-gray units form prominent ledges and are separated by smooth slopes underlain by thin- to medium-bedded sandy limestone. The sandy limestone and calcareous sandstone beds weather light brown to pink. Layers of hydroclastic limestone are common throughout the lower part of the formation but make up only a small part of the total thickness (Plate 3).

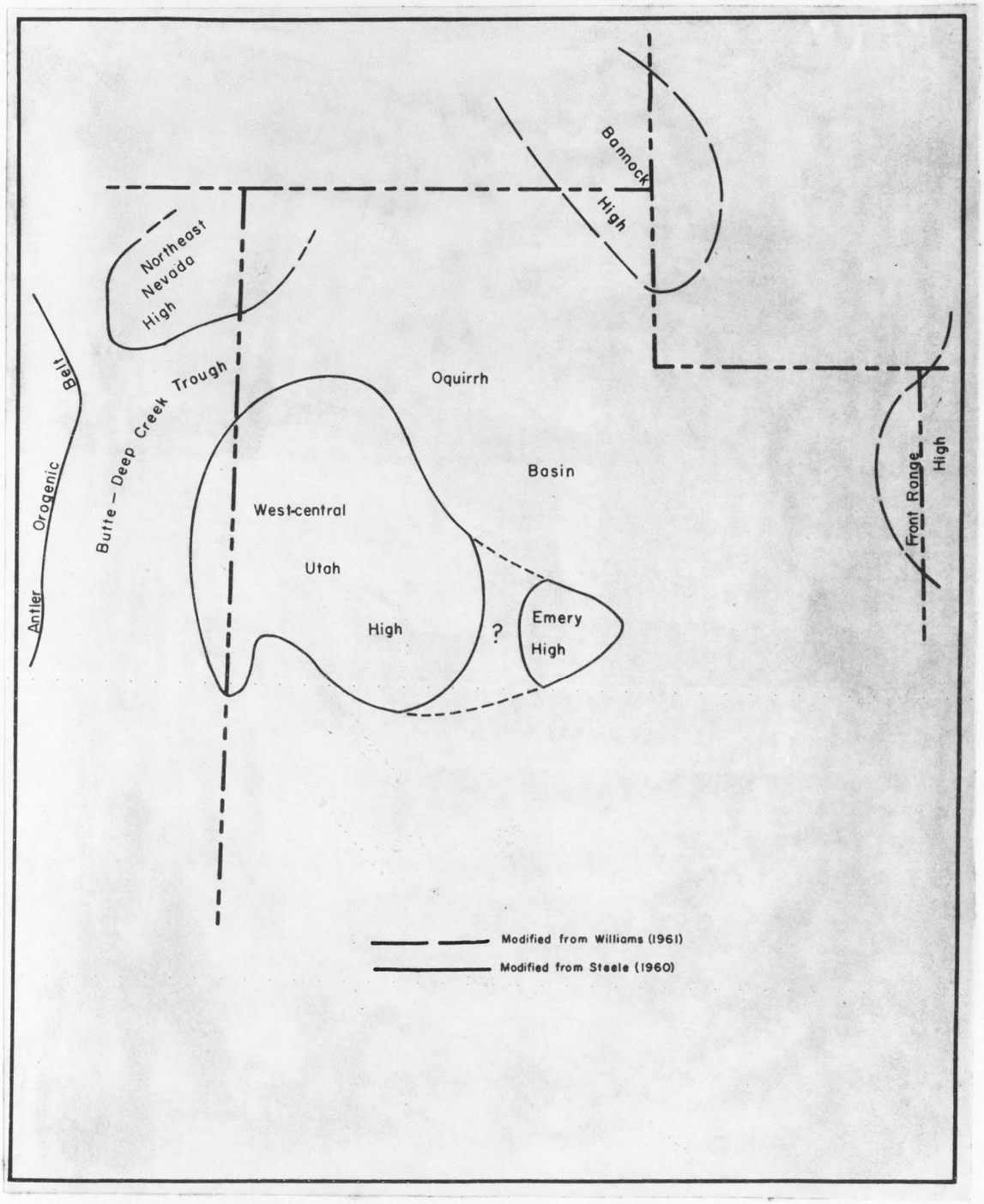


Figure 3. Paleotectonic map of Pennsylvanian-Permian systems.

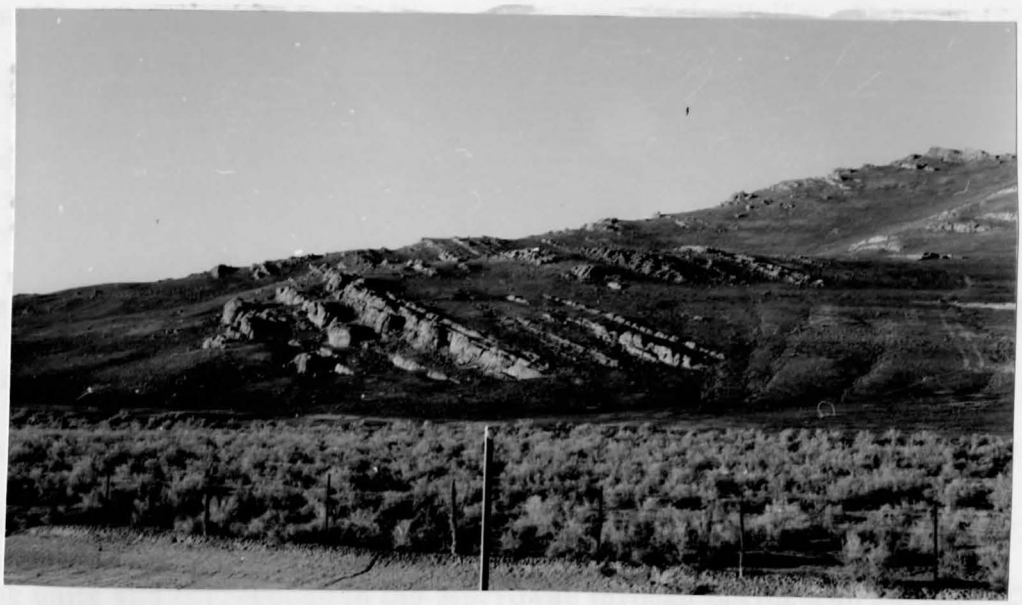


Figure 1. Typical outcrop of Oquirrh formation. Ledges are thick-bedded limestone, slopes are thin- to medium-bedded sandy limestone. Southeast corner of mapped area.

Figure 2. North end of west side of North Promontory Mountains. Ledges of Oquirrh formation are visible (arrows point to fault breccia shown on Plate 8).

Plate 3. Oquirrh formation.

From a comprehensive study of the Oquirrh formation in the southern Oquirrh Mountains and in Sardine Canyon near Cache Valley, Nygreen (1958, p. 13-15) distinguishes two members. The lower, West Canyon limestone member, consists predominantly of bioclastic limestones (more than 65 percent) with some interbedded sandstone or siltstone and lesser amounts of chert. Above this member the sandy Oquirrh consists of a thick sequence of sandstone, orthoquartzite, limestone, and minor amounts of mudstone. Bissell (1959, p. 93-127) designates five members of the Oquirrh formation in the southern Oquirrh Mountains. These members are essentially time-rock units and correspond to the Morrowan through Springeran series. The two lower members are essentially limestones and are overlain by alternating orthoquartzite and silty limestone units.

Within the area covered by this study it is evident that the dominant limestones of the lower part are overlain by a thick succession of alternating limestone, sandy limestone and orthoquartzite units. No abrupt change is seen, however, and the transition is very gradual. Orthoquartzite, sandy and silty limestone, and limestone constitute the dominant rock types of the upper part of the Oquirrh formation. Limestone units are medium gray and weather the same. Sandy units are medium gray and weather light brown to light gray. Cyclic sedimentation is noted in the upper part of the formation in near-by areas (Nygreen, 1958, p. 21; Bissell, 1959, p. 93-127). Distinct cycles of sedimentation have not been observed in the area covered by this present study. This may be due to poor exposures.

Paleontological study has proved helpful in correlation. As is recognized, the most important index fossils of the Pennsylvanian and Permian systems are the genera of the family Fusulinidae.

The following tabulations are of fusulinids collected and the age of each collection. Locations of these numbered collections are noted on the geologic map of the area (Plate 9).

Location 1.

Profusulinella cf. P. decora Thompson
Profusulinella cf. P. regia Thompson
Profusulinella aff. P. regia Thompson
Profusulinella n. sp.
Profusulinella sp.

Age: lower Atokan

Location 2.

Fusulinella sp.

Age: upper Atokan to lower Desmoinesian

Location 3.

Fusulina aff. F. rockymontana Roth and Skinner
Fusulina sp.
Wedekindellina cf. W. Matura Thompson
Staffella sp.

Age: lower Desmoinesian

Location 4.

Triticites collomensis Dunbar and Condra
Triticites cf. T. collomensis Dunbar and Condra

Age: middle Virgilian

Location 5.

Triticites sp.
"Pseudofusulinella fergusonensis" Slade

Age: upper Virgilian

Location 6.

Schwagerina n. sp.

Age: middle Wolfcampian

Location 7.

Schwagerina aff. S. steinmanni Dunbar and Newell
Schwagerina cf. S. tersa Ross
Schwagerina cf. S. extumida Ross
Schwagerina cf. S. vervillei Thompson
Rugofusulina sp.

Age: upper middle Wolfcampian to lower upper Wolfcampian

Several points are here offered in explanation of the above collections. Found in association with the fusulinids listed in Location 1 are Syringopora and Chaetetes. A lower Pennsylvanian "Zone of Chaetetes" has been the object of much study and discussion within the eastern Great Basin. Since it was first noted by Baker (1947) various workers have assigned Morrowan to Desmoinesian ages to it (Nygreen, 1958, p. 19). The species listed above, belonging to the genus Profusulinella, definitely indicate a lower Atokan age for the zone (Grant Steele, written communication).

With reference to Location 5, Steele (written communication) states he does not believe that the specimen identified as Pseudofusulinella fergusonensis Slade actually belongs to the genus Pseudofusulinella, but until a new genus name is published this name must be used for the taxonomy of

the specimen. The form is not uncommon and a genus name will undoubtedly be assigned to it by future workers.

Fossils collected from the Oquirrh formation that were not mentioned above are:

Chonetes sp.	Caninia sp. (?)
Neospirifer sp.	Leptozyga sp.
Rhipidomella sp.	Penniretepora sp.
Spirifer sp.	Fenestrellina sp.
Antiquitonia sp.	Turbulipora sp.
Linoproductus sp.	Warthia sp.
Crinoid stems	Leioclema sp.

Environment of deposition

The tectonic framework previously described controlled the sedimentation throughout the time the Oquirrh formation was being deposited. The subsidence of the miogeosyncline is evidenced by the great increase in thickness of strata in the eastern Great Basin over their equivalents on the shelf area to the east. Subsidence continued at a steady rate seldom exceeding the rate of sedimentation.

Work by Maxfield (1957) and Bissell (1959, p. 100) indicates that deposition occurred in epineritic and infraneritic seas. Numerous cross-bedded sandstone layers, occasional ripple marks, well-rounded particles, and uniform grain size of the sandstones indicate shallow water and the influence of moderately strong currents. The climate of the region during the deposition of the Oquirrh formation was mild and warm, possibly subtropical. Rogers (1957, p. 2-13) explains the necessity of warm climates for carbonate deposition. More vigorous erosion with possible increased uplift of the

source area and stronger oceanic currents probably combined to form the dominant sandy units during the middle and upper part of the Pennsylvanian and Permian Wolfcampian times.

Regional stratigraphy

Depositional patterns throughout the Pennsylvanian and Permian systems have been intensively studied in recent years. In general, Pennsylvanian and early Permian depositional patterns can be subdivided into two parts. These patterns trend generally north and south. There is certainly no abrupt change from one to the other but transition over broad areas can be seen. These patterns are: (1) the miogeosynclinal facies of central and north-central Utah and southern Idaho and (2) the shelf facies of east-central and northeastern Utah, western Wyoming, and southeastern Idaho.

The miogeosynclinal facies of the mapped area are similar to sections described by workers in the central Utah and south-central Idaho areas. The shelf facies to the east are much thinner and are more sandy.

While working on the economic geology of the Mercur mining district J. E. Spurr (1895, p. 347) described a sequence of Upper Carboniferous limestone and sandstone which he termed the "Upper Intercalated Series." To these rocks Gilluly (1932, p. 34) assigned the name Oquirrh formation. The type locality is in the southern Oquirrh Mountains in central Utah. Comprehensive studies have been made of the Oquirrh formation by Nygreen (1958) and Bissell (1959, p. 93-127). Each of these authors has named new members of the formation.

Nygreen studied the Oquirrh formation in the Oquirrh Mountains and in Sardine Canyon southwest of Logan, Utah. From this study, Nygreen named the lower part of the formation the West Canyon member and the much thicker upper part the sandy Oquirrh.

From exposures near the type area and from the Fivemile Pass quadrangle to the south, Bissell distinguishes five time-rock members. These are in ascending order: (1) Hall Canyon member, (2) Meadow Canyon member, (3) Cedar Fort member, (4) Lewiston Peak member, and (5) Pole Canyon member. These members respectively represent parts or all of the Morrowan, Atokan, Desmoinesian, Missourian, and Virgilian series.

While it is readily seen that in the mapped area the upper part of the formation is composed of much more sandstone than the lower part, the formation is not divided into members. The lowest beds are dominantly limestone but the transition through sandy limestone into predominant interbedded sandstone and orthoquartzite is extremely gradual.

A recent review of the Pennsylvanian system is offered by Williams (1962). In this detailed summary he outlines the paleogeography and correlates units present in the central and northern Rocky Mountains.

The Oquirrh formation attains the tremendous thickness of 26,000 feet in the Provo area and represents deposition from Morrowan to early Leonardian (Baker, 1947). At the type locality in the southern Oquirrh Mountains Gilluly (1932, p. 34) reports that the formation consists of more than 15,000 feet of interbedded limestones and coarse quartzites and sandstones. The author has measured over 3,000 feet of strata with neither base

nor top exposed. The formation is estimated to be about 8,500 feet in the Summer Ranch-North Promontory Mountain area.

Morrowan and Atokan deposition to the east of the Oquirrh basin formed the much thinner upper Round Valley limestone and the Belden formation. These formations represent the lower Pennsylvanian of southern Wyoming. In southeastern Utah and western Colorado, the red calcareous shales and sandstones of the Molas formation constitute this interval.

The thin Morgan-Weber sandstone facies of the central Wasatch Mountains represents the shelf equivalent of the Desmoinesian Oquirrh. The northern lithologic equivalent of the Weber sandstone is the Tensleep sandstone. The Tensleep grades westward into the sandy and cherty limestones and calcareous sandstones of the Wells formation in southeastern Idaho (Williams, 1962).

The Wood River formation of south-central Idaho was deposited in parts of the Desmoinesian, Virgilian, and Wolfcampian series and is the lithologic and time equivalent of the Oquirrh formation (Bostwick, 1955, p. 941-951). The Ely limestone and Strathern formation are chert-pebble conglomerates and cherty limestones of Morrowan to Desmoinesian age in northeastern Nevada (Steele, 1960, p. 91-113).

In southeastern Utah the Hermosa formation represents the upper-Pennsylvanian deposition. These beds are overlain by the Cutler formation. The lower part of the Cutler is sandstone and arkosic sandstone of Wolfcampian age.

The record of upper Permian sedimentation in the area surrounding the area covered by this study is not preserved. Little is known of the upper Permian in northwestern Utah. The Guadalupian Park City formation of north-central Utah and its southeastern Idaho equivalent, the Phosphoria formation, are noted for their phosphate deposits. Following the deposition of the Kaibab limestone in southern Utah and the Park City-Phosphoria phosphatic shales to the north, epirogenic uplift brought about a prolonged period of erosion which removed a large amount of late Permian sediments.

Tertiary Rocks

During Tertiary time the north-central Utah environment was continental in contrast to the marine environment of the entire Paleozoic era. During the late Cretaceous and earliest Tertiary, Laramide deformation folded the thick Paleozoic strata. Normal high-angle Basin and Range faulting followed. As reported by Rigby (1958, p. 114-115), the initial phase occurred in the Paleocene (?). Renewed movement along these fractures in Miocene and Pliocene elevated and tilted the mountain blocks. During the Miocene and Pliocene, valleys between these fault-block uplifts were covered by a thick blanket of tuffaceous sediments named the Salt Lake formation. Movement during the late stages of Basin and Range faulting has displaced the tuffaceous sediments covering the edges of the mountains, and structural adjustment of the area has continued until the present. Rough topography, much the same as that of today, existed when the tuffaceous rocks were deposited. Basalt flows were extruded during the late Miocene and Pliocene epochs.

Salt Lake formation

Tuffaceous beds of the Salt Lake formation crop out in wide areas around the southern end of the North Promontory Mountains and in a limited area in the central part of the Summer Ranch Mountains. This formation consists essentially of light-colored tuff, tuffaceous sandstone, and limestone-pebble conglomerate. The tuff is light-gray and occurs as thin- to thick-bedded layers interbedded with the light-gray to light-brown tuffaceous sandstone. The presence of delicate shards and glass bubbles indicates a calm site of deposition with little or no reworking of the sediments.

Lenticular beds of limestone-pebble conglomerate occur within the formation. They contain well-sorted pebbles of upper Paleozoic limestone in a tuffaceous matrix. The Salt Lake formation rests with marked unconformity on late Paleozoic rocks. The estimated thickness of the formation is 300-400 feet in the southern part of the North Promontory Mountains.

An Oligocene age was assigned to tuffaceous beds of the Salt Lake formation by Eardley (1944, p. 845). Upper Miocene and Pliocene beds are described in the Cache Valley area (Adamson, Hardy, and Williams, 1955, p. 1-10). No diagnostic fossils were found during the present investigation, but from similar exposures in surrounding areas a late Miocene and Pliocene age is assigned to the Salt Lake formation.

Environment of deposition

Deposition was on an irregular erosion surface. Topography was similar to that of today although some uplift of the mountain blocks elevated and

folded the Salt Lake formation. Adamson (1955, p. 42) describes the deposition of the Salt Lake formation as having occurred in lakes that were formed by damming of streams by the volcanic ash. Some lakes apparently covered quite large areas. Yen (1947, p. 269), in studying the molluskan fauna of the Salt Lake formation in the Bear River Narrows west of Cache Valley, reports that the thick oolitic limestone and the fauna present would have required a lake of large extent for their formation. The Salt Lake formation is thought to be a lacustrine and fluvial deposit.

Regional stratigraphy

The Tertiary Salt Lake formation crops out widely in northern Utah. Exposures in Morgan Valley east of Ogden City were named the Salt Lake group by Hayden (1869, p. 92). The rank of formation is generally accepted for these beds of light-colored tuff, tuffaceous sandstone, and limestone-pebble and limestone-cobble conglomerate. Vertebrate remains found by Eardley (1944, p. 845) clearly indicate an Oligocene age for the Norwood tuff, which is the lithological equivalent of the Salt Lake formation in this mapped area. From studies in Cache Valley, Adamson (1955, p. 4) assigns an upper-Miocene and Pliocene age to the formation. Mansfield (1927) applied the name Salt Lake formation to exposures of light-gray to buff tuffaceous sandstone and grit in southeast Idaho. Lenses of rhyolite are present in the formation in that area and Mansfield associates these with the Miocene rhyolite flows of Yellowstone National Park. Yen (1946, p. 485-494)

assigned a Miocene age to the Salt Lake formation on the basis of the molluskan fauna present.

In extreme northwestern Utah and adjacent parts of Idaho and Nevada, upper Miocene and lower Pliocene tuffaceous sediments are referred to the Payette and the Salt Lake formations (Mapel and Hale, 1956, p. 1-16). Exposures throughout central and north-central Utah and southeastern Idaho are similar lithologically. Strata referred to the Salt Lake formation in northwestern Utah contains more welded tuff than does the formation in the area covered by this report (Mapel and Hale, 1956, p. 1-16).

Basalt flows and associated tuffaceous rocks

Extensive lava flows cap thick accumulations of light-colored tuffaceous material in the north-central part of the mapped area (Plate 4). The tuffaceous sandstones and conglomerates were deposited on an irregular erosion surface. Marked angular unconformity between the folded and eroded Paleozoic rocks and the horizontal or gently dipping tuffaceous rocks is everywhere present. The tuffaceous material essentially filled the valleys creating a plane over which the basalt flowed in widespread sheets. Basalt rests directly on Paleozoic rocks in small local areas.

The relationship of the tuffaceous sediments, under the basalt flows, to the Salt Lake formation remains vague in the area covered by this report. The Salt Lake formation underlies the basalt in a limited area north of U. S. Highway 30S, about 9 miles east of Snowville, Utah. The basalt-associated tuffaceous material is not present in this area. Distinction is made between

Figure 1. Basalt flows overlie tuffaceous material. Note five distinct flows. Light-colored tuffaceous material is exposed at road cut along foot of slope. View looking northeast; U. S. Highway 30S in foreground.

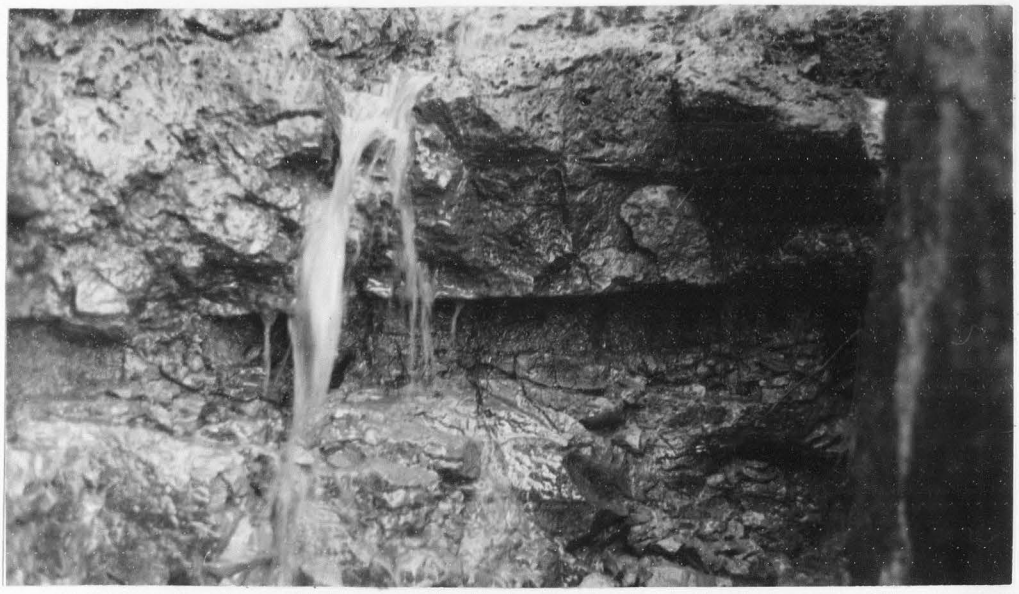


Figure 2. Baked tuffaceous sandstone immediately below basalt flow. Exposed in stream cut 1 1/2 miles south of U. S. Highway 30S, west side of North Promontory Mountains.

Plate 4. Basalt flows and tuffaceous rocks.

the Salt Lake formation and the basalt-associated tuffaceous rocks by the degree of sorting and color. The Salt Lake formation consists of light-gray tuff, tuffaceous sandstone, and well-rounded pebble and cobble limestone conglomerate. In comparison the tuffaceous material beneath the basalt flows exhibits a poor degree of sorting and medium-brown silt and clay size particles are mixed with lighter-colored tuffaceous sandstone. Lenticular conglomerate beds are composed of poorly sorted angular fragments of limestone ranging in size from granule to cobble. Cobbles of welded tuff also occur in the tuffaceous conglomerates.

The basalt is dark gray to black in color. It is vesicular to highly vesicular. The texture of the groundmass is aphanitic and is common to all flows observed. Small (1/2 to 2 mm) anhedral phenocrysts of olivine are present. The groundmass consists of labradorite and glass. Magnetite is the most abundant accessory mineral with subordinate augite. Maximum thickness of the flows is about 40 to 50 feet.

Extrusion of the basalt clearly post-dates Miocene-Pliocene deposition of the Salt Lake formation. Evidence is likewise clear that all igneous activity preceded Pleistocene Lake Bonneville (Plate 5). Well-developed terraces are cut into the basalt flows, and the Lake Bonneville group overlies the basalt. Smith (1953, p. 74) reports that the flows within the area covered by this report are the southward extension of the Snake River basalt flows of mainly late Pliocene age. Anderson (1931, p. 66) describes Snake River basalt flows in Cassia County, Idaho, and assigns the extrusions to the Early Pleistocene. The basalt is younger than the Salt Lake formation and older

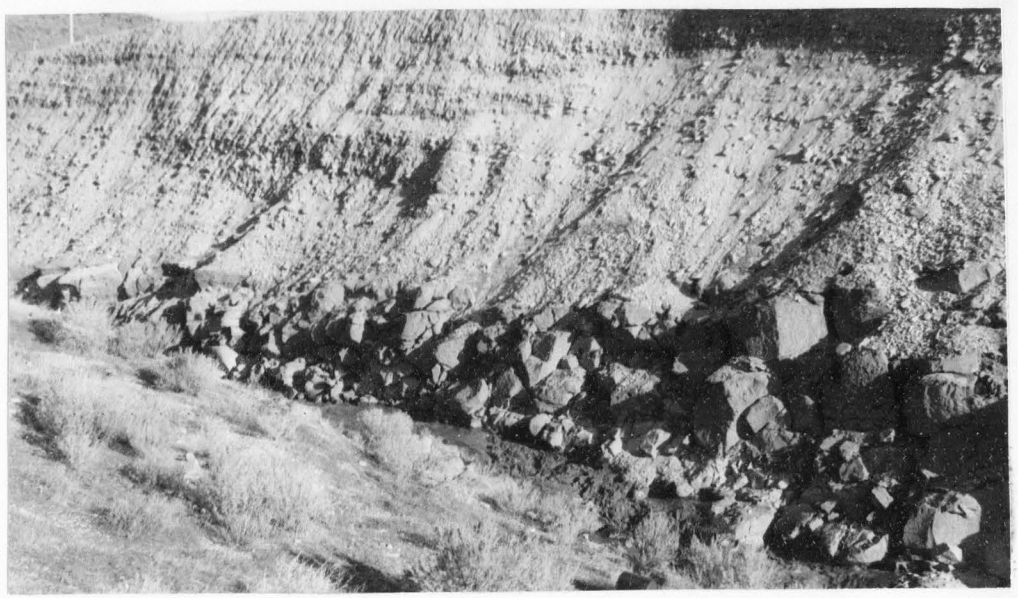


Plate 5. Basalt flow overlain by Lake Bonneville deposits. West side of North Promontory Mountains near U. S. Highway 30S.

than Lake Bonneville rocks and a late Pliocene age is assigned to it.

An accumulation of welded tuff is exposed in the north central part of the Summer Ranch Mountains. The outcrop is limited and difficult to study because of recent alluvial cover. The deposits are approximately 35 feet thick, unconformably overlie the Oquirrh formation, and are limited to an area of about 1 square mile.

Composition of the welded tuff compares to trachyandesite as defined by Johanssen (1932). Well-preserved glass shards are present in the groundmass. The refractive index of the glassy groundmass is about 1.530. The texture is vitrophyric. Pheoncrysts are subhedral biotite and labradorite. Cobbles of this composition are found in the tuffaceous material under the basalt flows near the north end of the North Promontory Mountains. The age of the welded tuff is therefore somewhat older than the basalt, probably late Miocene or early Pliocene.

Quaternary Rocks

The rocks of the Quaternary system consist mainly of unconsolidated clay, sand, and gravel. During the Pleistocene epoch a profound climatic change from the moderately warm temperate climate of the late Tertiary to one much colder in the glacial epoch occurred. Increased precipitation with the accompanying decreased evaporation created a system of fresh-water lakes in the Great Basin. This composite lake system is known as Lake Bonneville. The interior valleys of western Utah were filled to an elevation of about 5,135 feet. At this level, wide-spread terraces were cut into the

mountain blocks. Water of Lake Bonneville overflowed at Red Rock Pass at the northern end of Cache Valley and the lake surface was lowered by erosion of the outlet to an elevation of 4,770 feet (Williams, 1952, p. 1,375). Increasingly warmer temperatures and drier climates followed and the present Great Salt Lake is the largest remaining remnant of the older lake.

Recent time has been a period of erosion. Well-developed alluvial fans have been formed along the western side of the North Promontory Mountains. Sparse vegetation cover enables flood water from the spring thaw and irregular summer rains to remove weathered material from the mountain slopes at a remarkably fast rate.

Lake Bonneville group

Deposits assigned to the Lake Bonneville group are not differentiated into formations in the present investigation. The Bonneville shoreline is particularly well developed south of the Summer Ranch Mountains. Material composing the terraces consists of silt, sand, and gravel. In most exposures the gravel is well sorted and rounded. Some outcrops, however, consist of cemented breccia. Coarse material is eroded Paleozoic rocks. A well-developed soil profile is developed on many of the terraces and is cultivated in some areas. Spits and bars are composed of well-sorted sand and pebbles. Direction of the water currents is inferred from the location and shape of these structures to be toward the north.

Lake bottom material consists of sand, silt, and clay. The majority of this fine material is reworked Salt Lake formation (Plate 6).

Figure 1. Channel fill of well-sorted limestone-pebble conglomerate in reworked tuffaceous material of the Salt Lake formation (watch indicates scale). Exposed in stream cut 2 miles northwest of southeast corner of mapped area.

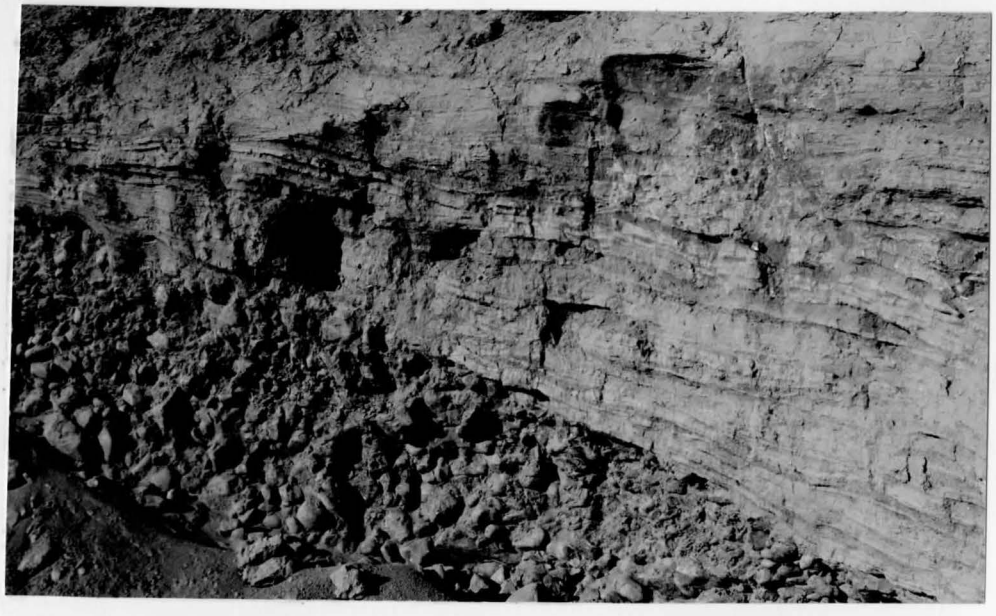


Figure 2. Tuffaceous sandstone overlies poorly sorted limestone conglomerate (watch indicates scale). Exposed in same stream cut as Figure 1 of this Plate.

Plate 6. Lake Bonneville group.

Recent alluvium

Undifferentiated soil, sand, and gravel filling the higher mountain valleys are mapped as Recent alluvium. No perennial streams are present in the mountains covered by this study. Alluvium is transported mainly by floods and slope wash from periodic summer rains and by runoff of the spring thaw. Sediments filling the aggraded valleys and boardering mountain slopes are covered in most places by a thin soil layer.

STRUCTURAL GEOLOGY

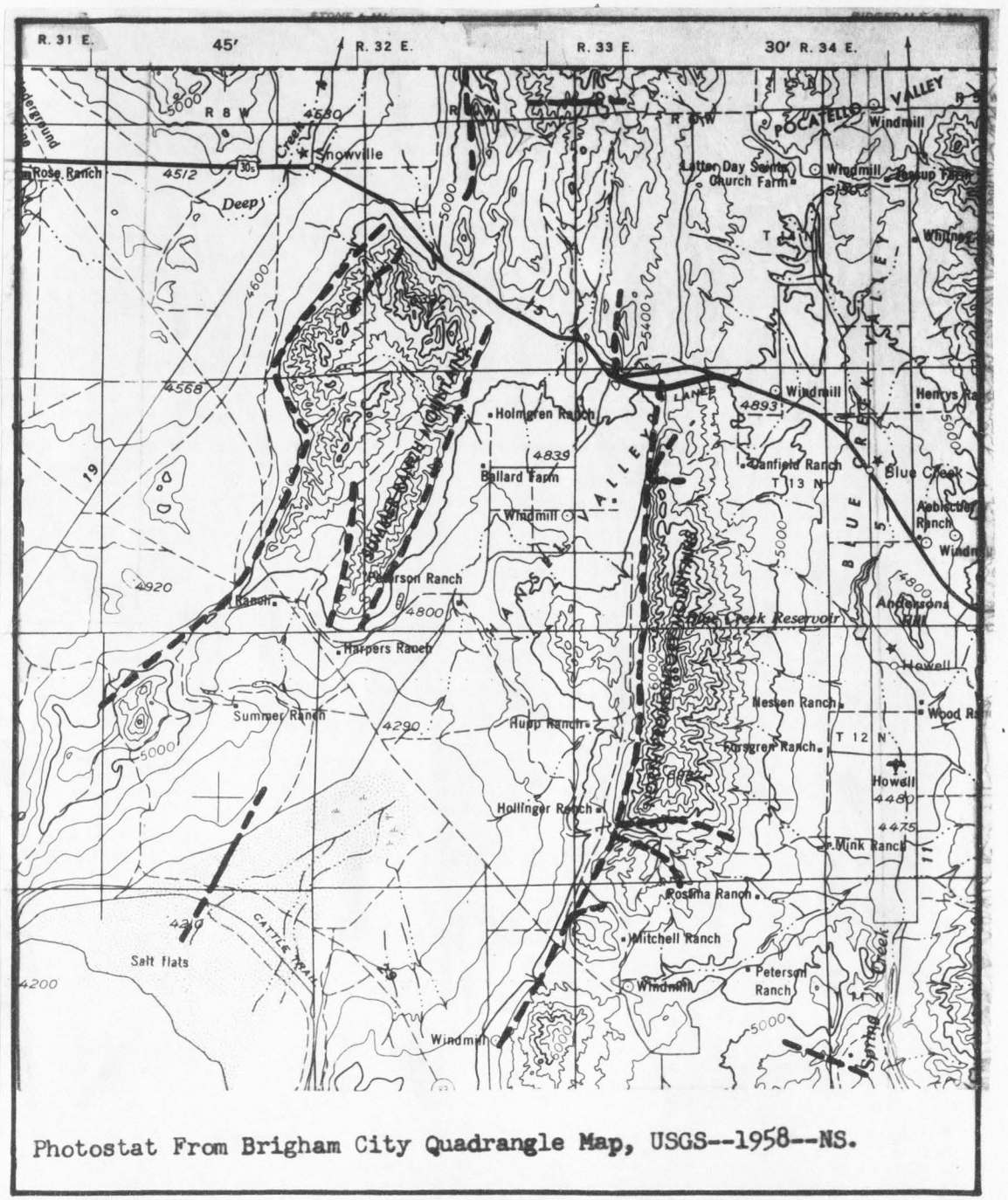
The mapped area lies within the eastern part of the Basin and Range province and exhibits typical fault-block structure. As described by Fenneman (1931),

> The distinctive features of the province are isolated, nearly parallel mountain ranges (commonly fault blocks) and intervening plains made in the main of subaerial deposits of waste from the mountains. These deposits although locally absent, are often very deep and are generally unconsolidated. (Fenneman, 1931)

Structural relations within the area studied are varied and offer many interesting features. For purposes of discussion the area has been subdivided into four structural units (Figure 4). These divisions are: (1) Summer Ranch Mountains, (2) Northern Area, north of U. S. Highway 30S, (3) North Promontory Mountains, and (4) Hansel Valley.

Summer Ranch Mountains

Gently folded Mississippian and Pennsylvanian strata form the bedrock of the Summer Ranch Mountains. Border faults limit both eastern and western margins of the mountain block. In the northwest corner Pennsylvanian strata dip 20^{o} to 30^{o} E. About three-fourths of a mile inside of the marginal fault this general dip is terminated against another high-angle fault. This second fault is subparallel to the western margin of the mountains. It dips steeply west and extends about 2 1/2 miles south-southwest from the northern



Photostat From Brigham City Quadrangle Map, USGS--1958--NS.

Figure 4. Tectonic map of area.

limit of the mountains. East of this fault, west-dipping Oquirrh strata are underlain near the eastern margin of the mountain block by the Manning Canyon formation. The Manning Canyon formation shows intense deformation. The upper contact is deformed and complicated by minor folding and faulting. The weak shales of the Manning Canyon have absorbed most of the deformational forces that only gently warped the Oquirrh formation. Local folds are common in the shales and the orthoquartzite beds often exhibit fault breccia. Due to the local nature of these features they have not been mapped. One major anticline is seen to extend the entire length of outcrop of the Manning Canyon. It is near the eastern margin of the mountain block and is convex toward the west.

Bedrock of the central and southern areas dips about 30^{o} SE. Strata of the southeastern spurs are elevated with respect to those of the west by a high-angle normal fault that extends from the south into the central part of the mountains. The Summer Ranch Mountain block is essentially a horst structure with its longitudinal axis trending about N. 25^{o} E.

A series of low hills to the south-southwest of the Summer Ranch Mountains exhibit the same general trend and are related to the same tectonic framework as the Summer Ranch Mountains.

Northern Area

Structurally the area north of U. S. Highway 30S is different than the remainder of the area. Mountains composed of Oquirrh formation reach an elevation of over 6,000 feet in the north-central part of this subdivision.

The western margin is limited by a typical north-south high-angle fault that is down on the west. Pennsylvanian strata exhibit a general east dip of 25° to 30°.

Roughly the southern half of this structural division is covered by Tertiary basalt flows. The flows overlie the Paleozoic rocks with pronounced unconformity wherever they are seen in contact. Throughout most of this area, the basalt flows are underlain by thick accumulations of tuffaceous sandstone and conglomerate. The attitudes of the tuffaceous material and those of the basalt flows are conformable. A gentle east dip of 5° to 10° is exhibited throughout the area of outcrop. The basalt flows form a resistant cap over the easily eroded tuffaceous material. The mesas thus formed show several landslide blocks. Smith (1953, p. 74) believes exposures of basalt in this area represent the southern extension of the Snake River basalt flows.

An east-west high-angle fault, found in the northeast corner of the area, is believed to have little stratigraphic displacement. Some left-lateral movement is shown by pronounced drag on both blocks. The low basalt-capped hills across the southern margin of this area form the northern limit of Hansel Valley.

North Promontory Mountains

One of the most outstanding structural features of the mapped area is the remarkably steep and straight western edge of the North Promontory Mountains. This fault-line scarp trends almost due north-south along the northern half of the mountains (Plate 7). In the southern half it swings gently

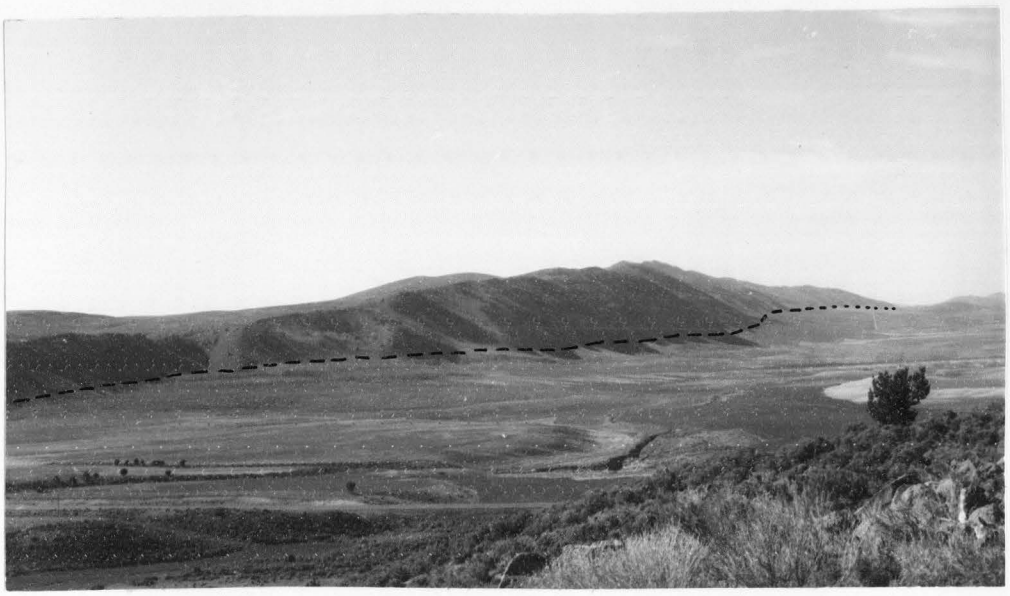


Plate 7. Fault-line scarp. West side of North Promontory Mountains, 3 miles south of U. S. Highway 30S.

to the south-southwest.

The fault plain is exposed in several places along the northwestern margin of the mountain (Plate 8). The strike of these isolated exposures ranges as much as 15° from the average strike of the scarp, indicating either an en echelon pattern of faults or a curved fault plain. The average dip is 73° toward the valley. Grooves on the pillars of fault breccia are not vertical, as might be expected, but are inclined about 20° from the vertical. Brecciated material constituting the pillars is made up entirely of limestone and sandy limestone of the Oquirrh formation. Cementing material is mainly calcium carbonate. Wherever the fault plain is exposed the breccia appears more resistant to weathering than the thin- to medium-bedded sandy limestone.

Southeast of the Hollinger Ranch two high-angle faults cut across the mountain range normal to the strike of the western boundary fault. These faults are both normal, deep steeply south, and are convex to the north. They drop the Salt Lake formation down against the Oquirrh formation in both cases.

Bedrock of the central North Promontory Mountains dips about 20° to 30° E. The two hills on the southern end of the North Promontory Mountains exhibit a general 30° dip to the south. Tertiary Salt Lake formation was deposited on the folded Paleozoic rocks with marked angular unconformity and has subsequently also been folded. A maximum dip of 65° is seen for Salt Lake formation exposures.

Figure 1. Cemented fault breccia in contact with Oquirrh limestone (arrow indicates hammer). Located on northwest side of North Promontory Mountains (see Plate 3, Figure 2, arrow at left side).

Figure 2. Cemented fault breccia. Ledge in upper right is Oquirrh limestone (man indicates scale). Located on northwest side of North Promontory Mountains (see Plate 3, Figure 2, arrow at right side).

Plate 8. Cemented fault breccia.

Two small hills in the southeast corner of the mapped area are folded into north-south anticlines. An inferred east-west fault separates the Pennsylvanian strata of the southern hill from the Mississippian strata of the northern block. The nature of the fault is not known except that the Oquirrh formation on the south is adjacent to the Great Blue limestone on the north. The author believes this fault is similar to the normal high-angle faults of east-west trend in the southern part of the North Promontory Mountains. The southern block is down in all cases and the trend is about the same.

Hansel Valley

Hansel Valley trends north-northeast from the northwest arm of the Great Salt Lake. It is a typical graben, being limited on the east and west by the border faults of the North Promontory and Summer Ranch Mountains. Recently active land subsidence has been measured in the southern part of the valley.

In 1934, the most severe earthquake in the recorded history of Utah was caused by movement along the north-south fault zone at the southwest side of the valley. Maximum vertical displacement along these fractures was 20 inches, with the valley moving down with respect to the hills to the west (Walter, 1934, p. 178-195). In 1850, Capt. Howard Stansbury (U. S. Topographical Corps) made an exploration of the Great Salt Lake. At that time the water level was at an elevation of 4,201 feet. Capt. Stansbury plotted the water line and also took several depth measurements in the bay near Hansel Valley. These data were reported and compared to results of

a similar survey made in 1934 by Adams (1938, p. 67). It was found that in the intervening period (84 years) the lake level had dropped 6 feet, but in three isolated areas at the margin of Hansel Valley the shoreline had transgressed the coast as much as a half mile. It was determined that a general subsidence of 4 feet had occurred over an area of several square miles (Adams, 1938, p. 68).

A series of bench-marks, along the original transcontinental railroad, were surveyed by the U. S. Coast and Geodetic Survey in 1911. After the earthquake in 1934, these levels were again surveyed across Hansel Valley and a maximum subsidence of 1.2 feet was reported.

A quotation is taken from the report by Adams.

> . . . . The difference in elevation of the land surface indicated by the levels between 1911 and 1934 is near the same magnitude of that of the observed displacements of recent earth cracks, and probably all subsidence for this period occurred coincidently with the earthquake. The subsidence since 1850, however, is three or more times as great, the other two-thirds apparently having occurred before 1911. (Adams, 1938, p. 70)

LITERATURE CITED

Adams, Thomas C. 1938. Land subsidence north of Great Salt Lake, Utah. Seismolog. Soc. America, Bull. 28:65-70.

Adamson, Robert D. 1955. The Salt Lake group in Cache Valley, Utah and Idaho. Unpublished MS thesis. Utah State University Library, Logan.

Adamson, Robert D., Clyde T. Hardy, and J. Stewart Williams. 1955. Tertiary rocks of Cache Valley, Utah and Idaho. Utah Geol. Soc., Guidebook to the Geology of Utah 10:1-10.

Anderson, Alfred L. 1931. Geology and mineral resources of eastern Cassia County, Idaho. Idaho Bur. Mines and Geology, Bull. 14:65-66.

Baker A. A. 1947. Stratigraphy of the Wasatch Mountains in the vicinity of Provo, Utah. U. S. Geol. Survey, Oil and Gas Inv. Chart 30.

Bissell, Harold J. 1959. Stratigraphy of the southern Oquirrh Mountains--upper Paleozoic succession. Utah Geol. Soc., Guidebook to the Geology of Utah 14:93-127.

Bostwick, David A. 1955. Stratigraphy of the Wood River formation, south-central Idaho. Jour. Paleontology 29:941-951.

Carr, Wilfred J., and D. E. Trimble. 1961. Upper Paleozoic rocks in the Deep Creek Mountains, Idaho. U. S. Geol. Survey, Prof. Paper 424-C, p. 181.

Crittenden, M. D., Jr. 1959. Mississippian stratigraphy of the central Wasatch and western Uinta Mountains, Utah. Intermountain Assoc. Petroleum Geologists, Guidebook to the Geology of the Wasatch and Uinta Mountains, 10th Ann. Field Conf. p. 63-74.

Eardley, A. J. 1944. Geology of the north-central Wasatch Mountains. Geol. Soc. America, Bull. 55:819-894.

Elias, Maxim K. 1937. Depth of deposition of the Big Blue (late Paleozoic) sediments in Kansas. Geol. Soc. America, Bull. 48:403-432.

Fenneman, Nevin M. 1931. Physiography of Western United States. McGraw-Hill Book Co., Inc., New York.

Gilluly, James. 1932. Geology and ore deposits of the Stockton and Fairfield quadrangles, Utah. U. S. Geol. Survey, Prof. Paper 173.

Hayden, F. V. 1869. Report on Colorado and New Mexico. U. S. Geol. Survey Terr., 3rd Ann. Rept. p. 92.

Hebertson, K. M. 1957. Some characteristics of the Manning Canyon formation in central Utah. Intermountain Assoc. Petroleum Geologists, Guidebook to the Geology of the Uinta Basin, 8th Ann. Field Conf. p. 78-81.

Johanssen, A. 1932. A descriptive petrography of the igneous rocks. University of Chicago Press, Chicago. Vol. 2.

Kay, Marshall. 1951. North American geosynclines. Geol. Soc. America, Mem. 48.

Mansfield, George Rogers. 1927. Geography, geology, and mineral resources of part of southeastern Idaho. U. S. Geol. Survey, Prof. Paper 152.

Maxfield, E. B. 1957. Sediments and stratigraphy of the Morrowan series in central Utah. Brigham Young University, Research Studies, Geology Series, Vol. 4, No. 1.

Mapel, W. J., and W. J. Hail, Jr. 1956. Tertiary stratigraphy of the Goose Creek district, Cassia County, Idaho, and adjacent parts of Utah and Nevada. Utah Geol. Soc., Guidebook to the Geology of Utah 11:1-16.

Moyle, Richard W. 1959. Mississippian and Pennsylvanian rocks, Manning Canyon shale. Utah Geol. Soc., Guidebook to the Geology of Utah 14:59-92.

Nygreen, Paul W. 1958. The Oquirrh formation, stratigraphy of the lower portion in the type area and near Logan, Utah. Utah Geol. and Mineralog. Survey, Bull. 61.

Olsen, Richard H. 1956. Geology of the Promontory Range. Utah Geol. Soc., Guidebook to the Geology of Utah 11:41-55.

Rigby, Keith J. 1958. Geology of the Stansbury Mountains, Tooele County, Utah. Utah Geol. Soc., Guidebook to the Geology of Utah 13:114-115.

Rogers, John. 1957. Distribution of marine carbonate sediments. Soc. Econ. Paleontologists and Mineralogists, Spec. Pub. No. 5, p. 2-13.

Sadlick, Walter. 1959. Illustrated sections of strata adjacent to the Mississippian and--Pennsylvanian boundary, western Uinta Mountains. Intermountain Assoc. Petroleum Geologists, Guidebook to the Geology of the Wasatch and Uinta Mountains, 10th Ann. Field Conf. p. 55-80.

Sadlick, Walter, and F. E. Schaeffer. 1959. Dating of an Antler Orogenic phase (middle Mississippian) in western Utah. (abstract) Geol. Soc. America, Bull. 70:1, 786.

Smith, Neil. 1953. Tertiary stratigraphy of northern Utah and southeastern Idaho. Intermountain Assoc. Petroleum Geologists, Guidebook to the Geology of northern Utah and southeastern Idaho, 4th Ann. Field Conf. p. 73-77.

Spurr, J. E. 1895. Economic geology of the Mercur mining district, Utah. U. S. Geol. Survey, 16th Ann. Rept., pt. 2, p. 343-355.

Steele, Grant. 1960. Pennsylvanian--Permian stratigraphy of east-central Nevada and adjacent Utah. Intermountain Assoc. Petroleum Geologists, Guidebook to the Geology of east-central Nevada, 11th Ann. Field Conf. p. 91-113.

Twenhofel, W. H. 1939. Environments of origin of black shales. American Assoc. Petroleum Geologists, Bull. 23:1, 178-1, 198.

Walter, H. G. 1934. Hansel Valley, Utah, earthquake. Sigma Gamma Epsilon, The Compass 14:178-195.

Williams, J. Stewart. 1952. Red Rock Pass, outlet of Lake Bonneville. (abstract) Geol. Soc. America, Bull. 63:1, 375.

Williams, J. Stewart. 1958. Geology of Cache County, Utah. Utah Geol. and Mineralog. Survey, Bull. 64, Geol. Atlas of Utah.

Williams, J. Stewart. 1962. Pennsylvanian system in central and northern Rocky Mountains. American Assoc. Petroleum Geologists. Pennsylvanian system in the United States.

Williams, J. Stewart, and James S. Yolton. 1945. Brazer (Mississippian) and lower Wells (Pennsylvanian) section of Dry Lake, Logan quadrangle, Utah. American Assoc. Petroleum Geologists, Bull. 29:1, 143-1, 155.

Yen, Teng-Chien. 1946. Late Tertiary fresh-water mollusks from southeastern Idaho. Jour. Paleontology 20:485-494.

Yen, Teng-Chien. 1947. Pliocene fresh-water mollusks from northern Utah. Jour. Paleontology 21:268-277.

APPENDIX

Section No. 1. Oquirrh formation. T. 14 N., R. 7 S. North end of Summer Ranch Mountains. Traversing west from valley edge, approximately 1 mile northwest of Ward Ranch.

Oquirrh formation		Thickness (feet)
13.	Sandy limestone, medium-gray, weathers same, medium- to thick-bedded, fusulinids	87.0
12.	Limestone, sandy, fine-grained, medium-gray, thin- to medium-bedded, and calcareous sandstone, light-brown, weathers same or pink. Neospirifer in limestone, also other brachiopods, crinoid stems, bryozoans, parts of trilobites, and rugosa corals	176.0
11.	Limestone, silty, and calcareous siltstone, medium- to dark-gray, platy weathering, forms slopes, weathers medium gray and light brown or pink	189.0
10.	Limestone, dense, medium- to dark-gray, massive, ledge-forming	146.0
9.	Silty limestone, medium- to dark-gray, thin- to medium-bedded, weathers medium gray and light brown to pink .	34.0
8.	Limestone, medium- to dark-gray, weathers same, massive, ledge-forming. 5 to 10 feet thick, medium-bedded layers of sandy limestone, with brown-weathering layers (1/16 to 1/4 inch) of fine-grained calcareous sandstone, ledge-forming	177.0
7.	Limestone, medium-gray, medium- to thick-bedded, dense, and some thin (1 to 3 feet) sandy layers near base	80.0
6.	Sandy limestone, very fine-grained, light- to medium-gray, thin- to medium-bedded. Calcareous sandstone, thin- to medium-bedded, light-brown, weathers light gray to light brown or pink	50.0
5.	Limestone, medium-gray, thick-bedded to massive, dense, contains brachiopods and bryozoans, forms ledges and slopes, weathers medium gray	243.0

Section No. 1. (Continued)

		Thickness (feet)
4.	Limestone, medium-gray, massive, dense, contains some 2- to 3-inch irregular shaped chert nodules, weathers dark gray, contains brachiopods and corals . .	60.0
3.	Limestone, light-gray, massive, weathers gray and light brown, contains crinoid stems and bryozoans . . .	124.0
2.	Sandy limestone, medium-gray, fine-grained, weathers medium gray. Calcareous siltstone, pinkish-brown, thin- to medium-bedded, weathers pink	30.0
1.	Limestone, medium- to dark-gray, fine-grained, thick- to massive-bedded, ledge-forming, weathers medium gray	25.0
	Total	1,421.0

Section No. 2. Oquirrh formation. West side, north end of North Promontory Mountain Range. Traversing south-southeast from valley edge about 3 miles south of U. S. Highway 30S.

Oquirrh formation		Thickness (feet)
14.	Sandy limestone, medium-gray, very fine sand grains, finely crystalline, forms 2- to 3-foot irregular ledges and slopes	263.0
13.	Sandy limestone, medium-gray, very fine sand grains, massive, some light-brown-weathering silty limestone, highly fractured, 20 foot cliff	108.0
12.	Covered slope, blocks of 6-inch to 1-foot calcareous sandstone and siltstone. Fault breccia at top of unit . .	89.0
11.	Calcareous sandstone, tan to pink, fine laminae in medium-gray, sandy limestone, forms irregular series of 2- to 3-step-like ledges. Minor cross-beds and contorted bedding in the sandy limestone	295.0
10.	Sandy limestone, medium-gray, very fine sand grains; some calcareous siltstone and massive silty limestone, weathers tan	207.0
9.	Limestone, sandy, medium- to dark-gray, weathers medium gray, very fine sand grains, minor amounts of light-brown calcareous siltstone, forms massive cliffs; silty layers are 6- to 8-inches thick and are less resistant than the 6-inch to 8-foot thick limestone layers separating them. Irregular brown bands up to 1-inch thick show on weathered face of limestone sliff, these are separated by 1-foot thick medium-gray bands	76.0
8.	Covered slope, blocks of medium-gray, sandy limestone, and chips of pink- to light-brown-weathering quartzitic sandstone up to 6 inches across, and blocks of basalt up to 18 inches across	248.0
7.	Limestone, medium-gray, finely crystalline, very fine sand grains, massive cliff, weathers medium gray to light brown, fusulinids in lower 20 feet	91.0

Section No. 2. (Continued)

		Thickness (feet)
6.	Covered slope, blocks of medium-gray limestone, light-brown sandy limestone, and basalt	219.0
5.	Limestone, medium- to dark-gray, medium-crystalline with very fine sand grains, massive, weathers medium gray. Fusulinids at base and 65-feet above base. Becomes more sandy at top	98.0
4.	Covered talus slope. Medium-gray to light-brown, sandy limestone blocks up to 1 foot across. 1-foot unit of medium-brown weathering siltstone at top	63.0
3.	Silty limestone, medium-gray, finely crystalline, and pink and yellowish-brown siltstone in 2- to 6-inch tabular chips, slope-forming	49.0
2.	Sandy limestone, medium-gray, very fine sand grains, layers are 6 inches to 3 feet thick, ledge-forming . . .	38.0
1.	Calcareous siltstone, pink, weathers same, 1- to 2-foot beds alternating with medium-gray 3-inch to 1-foot beds of medium-crystalline limestone with very fine sand grains, ledge-forming, sandy limestone	12.0
	Total	1,846.0

Section No. 3. Manning Canyon formation. NW 1/4, T. 13 N., R. 7 W. Summer Ranch Mountains. Traversing south from first outcrop above canyon bottom, half a mile east of spring troughs.

Oquirrh formation

Conformable contact

Manning Canyon formation		Thickness (feet)
14.	Shale, black to dark-gray, weathers medium to light brown; silty to fine sandy interbedded limestone	14.0
13.	Orthoquartzite, medium-gray, silica grains are sub-rounded to rounded, well-sorted, and of medium sand size, unit forms ledges, weathers medium gray in lower 40 feet and dark brown in upper part	187.0
12.	Shale, black, clayey, weathers light brown	38.0
11.	Siltstone, dark-gray, thin- to medium-bedded, weathers medium to light brown	34.0
10.	Siltstone, light-gray to light-brown, thin-bedded, weathers light brown	14.0
9.	Shale, black to dark-gray, weathers dark gray	19.0
8.	Siltstone, light-gray, medium-bedded, forms ledges, weathers light brown	24.0
7.	Shale, black, weathers brown to dark gray	72.0
6.	Orthoquartzite, medium-gray, weathers light gray to medium blue gray	20.0
5.	Quartzitic sandstone, medium- to fine-grained, light-gray, occurs in 6- to 8-inch beds, weathers medium brown. Siltstone, medium-gray, thin-bedded, individual units are 3 to 4 feet thick, weathers medium gray . . .	56.0
4.	Orthoquartzite, medium-gray, weathers light brown . .	5.0

Section No. 3. (Continued)

		Thickness (feet)
3.	Interbedded siltstone and orthoquartzite. At bottom of unit, 4- to 5-inch siltstone layers are interbedded with 1- to 2-inch orthoquartzite layers; thickness and frequency of orthoquartzite layers increase upward and near top of unit 6-inch orthoquartzite layers are separated by 1/2-inch to 1-inch siltstone layers, unit forms ledge .	14.0
2.	Shale, black to dark-gray, weathers light brown to pink; minor thin silty beds near top	20.0
1.	Shale, black, forms slopes, weathers black to medium brown	179.0
	Total	696.0

PLATE 9

EXPLANATION

QUATERNARY

Qa RECENT ALLUVIUM

Unconsolidated detrital sediments

Qlb LAKE BONNEVILLE GROUP

Terrace gravel and lake-bottom sediments

TERTIARY

Tb BASALT

Vesicular olivine-basalt, aphanitic dark-colored

Tt TUFFACEOUS ROCKS

Poorly consolidated tuffaceous sandstone with interbedded pebble and cobble conglomerate

Twt WELDED TUFF

Composition of trachyandesite. Vitrophyric texture, subhedral biotite and labradorite phenocrysts

Tsl SALT LAKE FORMATION

Light-gray-to light-brown tuff, tuffaceous sandstone and limestone-pebble conglomerate

PENN—PERMIAN

PPo OQUIRRH FORMATION

Limestone, sandy limestone, sandstone, and orthoquartzite. Percentage of sand increases upward

MPmc MANNING CANYON FORMATION

MISSISSIPPIAN

Interbedded light-brown orthoquartzite and dark-gray and black shale. Orthoquartzite weathers dark-brown

Mgb GREAT BLUE LIMESTONE

Blue-gray, massive, limestone. Minor thin shale beds

Fault

Anticline

Contact

Fusulinid locality

IDAHO

UTAH

42° 00' Lat.

41° 45' Lat.

112° 45' Long.

112° 30' Long.

R 8 W

R 7 W

R 6 W

T 14 N

T 13 N

T 12 N

T 11 N

CURLEW VALLEY

SUMMER RANCH MTS.

HANSEL VALLEY

NORTH PROMONTORY MOUNTAINS

BLUE CREEK VALLEY

GREAT SALT LAKE

Snowville

Ward Ranch

Holmgren Ranch

Ballard Ranch

Canfield Ranch

Blue Creek

L. D. S. Farm

Peterson Ranch

Harpers Ranch

Summer Ranch

Hupp Ranch

Hollinger Ranch

Reese Ranch

Peterson Ranch

Blue Creek Reservoir

Howell

Nessen Ranch

Forsgren Ranch

Mink Ranch

Rostma Ranch

Salt Plant (abandoned)

Promontory

30S

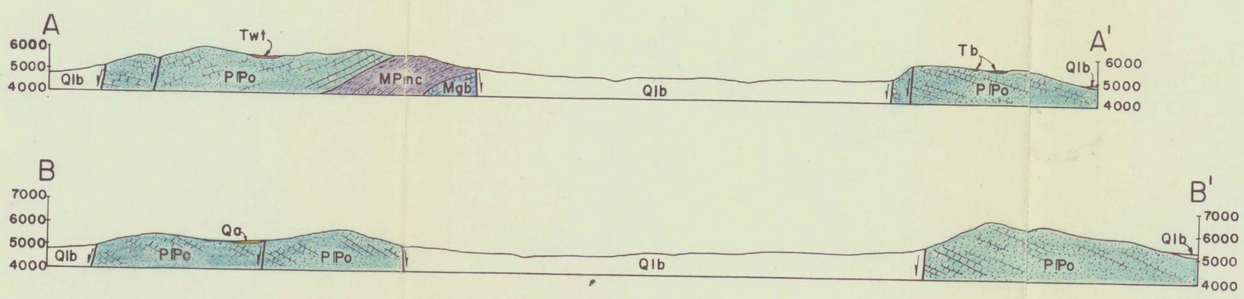
83

A

A'

B

B'



GEOLOGY OF THE SUMMER RANCH AND NORTH PROMONTORY MOUNTAINS, UTAH

O. CLAIR ADAMS

1962

SCALE 1:62500

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